

INVERCON

INNOVATIVE NITTANY VALLEY ENGINEERING, RESEARCH AND CONSULTING

Lightweight, Low Power, Miniature Trailing-Edge Effector (MiTE) Actuator using Existing On-Blade Pressure Differentials

Principle Investigator

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What are MiTEs?

- **Miniature Trailing-Edge Effectors (MiTEs) are an extension of a passive high-lift device, the Gurney Flap**
- **In rotorcraft, MiTEs have potential to improve:**
 - **Rotor Performance**
 - Increase lift to reduce retreating-blade stall
 - Reduce compressibility effects on advancing side
 - Tailor spanwise lift distribution to minimize power
 - **Vibration Control**
 - Spanwise & Azimuthal Lift Distribution

Race Car Gurney Flap



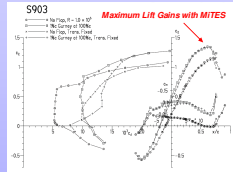
Conceptual Rotorcraft MiTEs



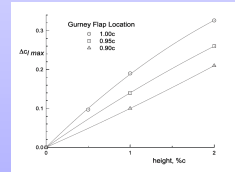
MiTE Aerodynamic Effects

- **Aerodynamic tests have been conducted in PSU's wind tunnel**
- **MiTEs significantly increase pressure on the lower surface upstream of the flap**
- **Downstream of the flap, strong favorable pressure gradient leads to a trailing edge pressure lower than the baseline airfoil**
- **On upper surface, MiTEs postpone start of pressure recovery by 20%, causing longer regions of laminar flow**
- **Maximum lift gains are achieved in large part due to lower-surface pressure increases upstream of the MiTE location**

Static Aerodynamic Testing



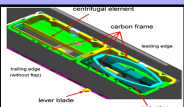
Performance vs. Chordwise Position



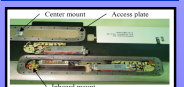
Comparison to Trailing Edge Flaps

- **Trailing edge flaps have been proposed for individual blade control**
 - Flaps used to generate desired unsteady aerodynamic load at N/rev, or 20-30 Hz
- **MiTEs offer similar lift and moment performance benefits as trailing edge flaps, but:**
 - Trailing edge flaps require high force actuators, typically piezoelectric-based
 - Heavy power amplification systems
 - Distributed MiTEs require dramatically lower actuation loads
 - Low voltage, no extra power amplification systems required
 - MiTEs are insensitive to compressibility effects

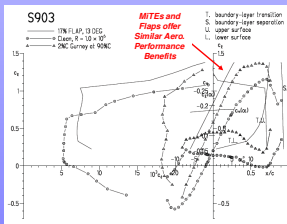
Eurocopter Piezo Stack Actuator



Double X-Frame Actuator

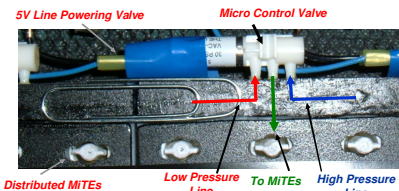


Aerodynamic Performance of MiTE vs. Flap



Invercon's Pressure Actuated MiTE Concept

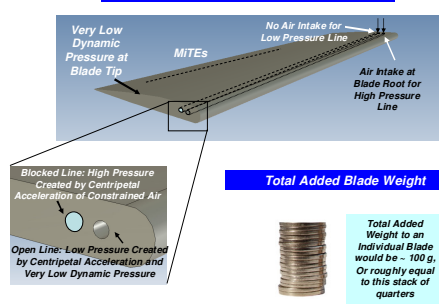
- **Invercon proposes an innovative MiTE actuator design powered by on-blade pressure differentials**
 - Simple, dramatically low weight penalty design
 - High pressure and low pressure lines connected to micro, three-way pressure valves
 - Valves semi-actively toggle between high and low pressures at desired high frequency (up to 100 Hz) to actuate MiTEs
 - Low Voltage: Current valves require only 5V
 - No extra power amplification systems needed



On-Blade Implementation

- **Invercon proposes to use pressure differentials created by the spinning rotor to actuate the MiTEs**
- **High pressure would be created using the centripetal acceleration of the air within the blade**
- **Low pressure would be created by utilizing the very low dynamic pressure at the blade tip**
 - Because dynamic pressure varies with velocity squared, this pressure would be lower than inboard dynamic pressures, enabling effective MiTE actuation
- **Total added weight to an individual blade would not exceed 100 g, or 0.2 lbs.**
- **This is approximately 100 times less than trailing edge flap actuation when accounting for onboard power amplification**

On Blade High and Low Pressure Sources



Total Added Blade Weight

Total Added Weight to an individual Blade would be ~ 100 g, Or roughly equal to this stack of quarters

Predicted On-Blade Pressure Generation

